HABITS OF BELOSTOMA (=ZAITHA) FLUMINEUM SAY AND NEPA APICULATA UHLER, WITH OBSERVATIONS ON OTHER CLOSELY RELATED AQUATIC HEMIPTERA.

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Collection of Material.—Belostoma flumineum inhabits ponds or sluggish streams. While specimens were often captured, in our experience, in shallow water a few inches in depth, they were frequently taken in deeper waters. During early autumn before the leaves had fallen, this aquatic hemipteron was often obtained by raking out floating masses of vegetation from the water; it was also found below the thick scum of surface algæ which were taken from a stream or pond and turned over on the shore. Later in fall, specimens were captured by scooping up with a water-net the leaves which were floating on, or had sunk below the surface of the water. After the water was covered with a thin coating of ice, these insects were taken by pulling up with a rake the sediment on the bottom of the stream or pond, or the roots of grass and mud along the bank. Some of the bugs, which happened to escape by this method, were caught by making a rapid current in the water with a net and then suddenly reversing the movements of the net by scooping against the current. A large number of individuals, when taken out of the water by any of these methods, would not feign death, but would right themselves, if they happened to drop on their backs, and scramble eagerly to escape. Many, however, were found while feigning death, although often with great difficulty, either on account of their rather close resemblance in color to the leaves that had fallen into the water or to the mud which often coated the insects.

As Bueno (7, p. 138) has observed, *Nepa apiculata* "is found in quite shallow water, not much over two or three inches deep, concealed in the mud, or in situations where grasses grow out of the

water, clinging together." When raked out of the water together with the mud and partially decayed vegetation, these insects usually feign death, in which condition they readily escape detection, as their flat bodies are effectively concealed by the black mud and decaying plant tissue. It is only when the insects come out of the death feint and move about that they are usually seen, but even then one must watch closely, for their protective resemblance is remarkably good.

Fear.—A sudden approach towards an aquarium containing Belostomas recently brought into the laboratory sets them off from their resting places, fleeing in all directions. A large number of these hemiptera were placed in an aquarium containing bits of wood, such as pieces of shingles. Many of the water-bugs would crawl out of the water upon these floats, and upon our approach the insects would sometimes hurry to the edge of the board and plunge into the water with all the appearance of violent alarm. Specimens, which had not been disturbed over night, exhibited the same hurried movements to get to the bottom of the aquarium the next morning when approached by a large object, such as a black hat. Undoubtedly we may say from these outward appearances that *Belostoma* manifests fear.

Nepa apiculata, Ranatra americana[1] and *Ranatra kirkaldyi* show no sign of fear in its more usual manifestations.

Thigmotactic Response.—It was often noticed that *Belostoma* will crawl below objects lying on the bottom of the aquarium whenever possible. Large flat corks, four inches in diameter, were thrown into

[1] Mr. J. R. de la Torre Bueno has kindly called our attention to the fact that A. L. Montandon makes a new species of what we know as *Ranatra quadridentata,* viz., *Ranatra americana,* and synonymizes *Ranatra kirkaldyi* Bueno with *Ranatra fusca* P. B. Regarding these changes in nomenclature, Bueno wrote us as follows: "Montandon in his 'Notes sur quelques formes Nord-Americains du genre Ranatra,' Bull. de la Soc. de Sci. de Bucarest, Rumanie, XIX, p. 64, describes *R. americana,* which he identifies with what, following Uhler, we have been calling *quadridentata,* Stål; and he synonymizes my *R. kirkaldyi* with *fusca,* P. B. Montandon's method of identifying by a figure and not by a description, seems to me too far-fetched. As a matter of fact, I have in my collection two other species which can be identified with the description of *R. fusca,*—one from the South, and another local one, which I have also received from the West. To me, the question can best be resolved by determining where Beauvois got his examples. Until this is done, I much fear that I shall continue to regard my *kirkaldyi* as a distinct species and that *fusca* is still to be determined and fixed."

an aquarium in which the water was but an inch in depth, and within a few hours thirty-two of the thirty-five specimens that the aquarium contained were found beneath the corks. Again, it was not unusual to find two or more Belostomas or sometimes large clusters clinging together at the surface or bottom of the water, a characteristic which is also noticed with *Lethocerus* (=*Belostoma* Aucct.) *americanum, Benacus griseus, Nepa apiculata, Ranatra americana* and *Ranatra kirkaldyi.* This habit is probably a manifestation of their thigmotactic response.

Food Reactions.—Belostoma is carnivorous. While resting at the surface-film of the water, it often seizes its prey with the front pair of raptorial legs. When in the resting position, the body extends obliquely down in the water, the posterior extremity of the abdomen being held slightly above the surface-film, while the front legs are held some distance below. In this attitude the front legs, slightly bent at the femoro-tibial joint, are extended forward on each side of the head; the femora of the middle and hind legs are extended outward at almost right angles to the long axis of the body, while the tibiæ of these legs form an obtuse angle with the femora. The front legs are thus in readiness to grab the prey, while the two posterior pairs are ever ready to propel the bug forward instantly at the slightest disturbance.

In procuring food, *Belostoma* does not depend entirely upon the sense of sight. We have often observed a back-swimmer or a water-boatman come to rest on the ventral surface of *Belostoma,* and were surprised at the number of times the prey escaped. If a back-swimmer or a water-boatman strikes against *Belostoma,* the latter makes a quick grab for it, and, if successful in capturing it, proceeds to suck out the juices. Often, however, a back-swimmer or a water-boatman is grabbed at as it passes near a *Belostoma* without coming in actual contact with it. Holmes (23, p. 160) finds that in the young of *Ranatra quadridentata,* "this action is probably a response to the impact of the water. If a *Ranatra* is hungry, touching the surface-film with a needle near the insect will often cause it to grab about wildly in the effort to seize whatever may have caused the disturbance." The same experiment was performed with a mature *Belostoma* which had been starved for a number of weeks, and so rapid was the reaction, that only the bug was observed clinging to the needle after the surface-film had been touched with it. Both eyes of a *Belostoma*

were now cut off, and shortly after the operation a honey-bee with vibrating wings was placed upon the surface-film near the bug, whereupon the latter responded by rapidly opening and closing the claw-like tibia and tarsus of the front legs. The next morning the surface-film near the aquatic bug was touched with a needle and the same reaction was given. By repeatedly touching the surface-film with a needle in front of this hemipteron deprived of its eyes, the bug could be induced to swim towards the needle and at the same time it would endeavor to grasp the source of disturbance.

Flies with one wing amputated were dropped near Belostomas resting at the surface of the water and were often seized so quickly and so suddenly that the eye was unable to follow the exact movements. If the bug was not hungry, however, the dipteron was able to swim about upon the surface-film within easy reach of the raptorial legs of *Belostoma* without provoking any attempt to capture the fly, If a fly, swimming on the surface of the water, happens to crawl upon this hemipteron, it may stimulate the bug to swim away, leaving the fly behind; or, if by chance, it reaches a position near the head of *Belostoma,* it may be seized by one of the raptorial legs. Should the fly be seized by one of its legs and endeavor to free itself, the other raptorial leg of the bug will often clutch the victim around the body. Bueno (10, p. 191) has observed that at times all three pairs of legs "are employed to hold fast some powerful insects or large victim, such as a snail." Having obtained a good grip, the water-bug draws the prey below its head to the beak. The fly may then be moved about by the raptorial legs as the terminal end of the proboscis touches the dipteron here and there, as if seeking a suitable place to insert the piercing organ. While holding the prey with its front legs, *Belostoma* proceeds to suck out the juices of its victim, and even when disturbed will usually not drop the fly, but will swim about very actively, retaining possession of its meal.

At times, a *Belostoma* resting at the surface-film, will leave its resting place without any apparent cause and begin to swim actively about. If the hemipteron should happen to swim to the bottom of the aquarium and by chance come to rest upon a dragon-fly nymph, not too large, the bug may again enjoy a meal; for as the nymph squirms about endeavoring to free itself of its burden, *Belostoma* may clutch it tightly and sink its styliform mandibles and maxillæ into its victim.

This predaceous water-bug feeds upon a variety of animals found in its environment. The aquatic insects most abundantly captured, as revealed in our aquaria, were the back-swimmers and water-boatmen. According to Weed's (39, pp. 11–12) observations, the most important element of food as noticed in his aquaria, "consisted of the larvæ and nymphs of dragon-flies (Libellulidæ). The next most abundant victim was the common undulating back-swimmer (*Notonecta undulata*). . . . Univalve snails also occasionally contribute to the diet of this insatiable creature, as one was observed feeding upon a small snail with a spiral shell. May-fly larvæ (Ephemeridæ) also sucks out the juices of its own kind. On rare occasions we observed (10, p. 191), however, noticed that *Belostoma* often seizes and form part of its food, as was shown by similar observations." Bueno a mature form of this bug with its piercing organs penetrating the soft chitin and sucking out the juices of a *Belostoma* which had recently moulted and become full grown. While the older mature individuals will live together for a long time, rarely devouring one another, they will attack and suck out the juices of their own young. If young Belostomas of different sizes are placed in an aquarium, the smaller ones will be exterminated in a short time.

Nepa is also carnivorous. It will reach for its prey with its raptorial legs, but in no instance could this aquatic bug be induced to swim or run after its prey. If a house-fly or a dragon-fly nymph is carefully and slowly brought towards the front legs, the claw-like tibiæ and tarsi slowly move away from the femora. If they are already extended and well separated, as is often the case, the insect usually remains perfectly quiet until the prey is actually placed between the outstretched legs, when suddenly it is seized and securely held. The piercing-organs are then inserted into a soft part of the body and the insect begins to feed. It will also grasp the tip of a pencil when this is slowly and carefully placed between the outstretched front legs. If, however, a fly, dragon-fly nymph or a pencil is quickly and suddenly presented to the hemipteron, it will usually draw back its front legs, folding the tibia and tarsus back into the groove of the femur.

Nepa will not only use smaller animals than itself as food, but it will also feed upon dragon-fly nymphs considerably larger and

stronger than itself, the struggles of the dragon-fly nymphs usually ceasing within a short time after the piercing organs of a *Nepa* have been pushed into their bodies. That this is the effect of a fluid which *Nepa* injects into them was only too well demonstrated on ourselves. While one of us was carelessly holding several Nepas in a closed hand, one of the insects suddenly punctured the palm, causing an intense pain and soon afterward a considerable swelling. Locy (32, pp. 355–6) has found in the genera *Lethocerus, Belostoma* and *Ranatra* what he calls the "cephalic glands," which may be the source of a poisonous secretion. "When these insects are irritated, a secretion is freely thrown out around the base of the beak, which produces death very quickly when introduced on a needle point into the body of an insect."

Respiration.—Belostoma will often leave its resting place in the water and swim to the surface to obtain a fresh supply of air. During this respiratory act, one may notice a pair of strap-like appendages protruding above the surface-film from the posterior end of the abdomen; within a short time these are retracted and usually withdrawn from sight. If the wings of this aquatic bug are raised while the insect is below the surface of the water, a silvery coating of air will be noticed on the dorsal side of the abdomen. Unquestionably *Belostoma* carries a reserve supply of air between the wings and the abdomen. If a specimen emersed in water is examined under a binocular microscope, one can readily see that the pubescence described by Bueno (10, p. 192) on the under surface of the body holds a thin film of air, which probably supplies the abdominal and thoracic spiracles.

Uhler (27, p. 255) in writing of the family Belostomatidæ says: "A remarable feature of all the genera is in the presence of a pair of flattened, narrow, strap-like appendages at the end of the body which are extensible, but not concerned with respiration . . . ." Bueno (10, p. 192), however, found near the base and below the outer edge of each strap-like appendage in *Belostoma flumineum,* "a deep sunk orifice in which lies the great spiracle from which springs the large tracheal trunk of the main system."

When Belostomas are disturbed while taking in a new supply of air, some specimens will spurt forth, on rare occasions, a stream of

liquid material from the caudal end of the abdomen. Occasionally an individual will do the same thing when taken suddenly out of the aquarium. For a long time we were under the impression that water had accumulated beneath the wings and that this was forcibly ejected in some way. Recently a *Lethocerus americanum* was suddenly taken out of the water and it also spurted forth a stream of liquid, which happened to strike the nose of one of us and, from the peculiar odor, we concluded that the ejection of the stream is due to a forcible discharge of the contents of the rectum.

A number of experiments were performed in order to determine the length of time *Belostoma* and *Ranatra* can remain alive below the surface of the water. Ten specimens of *Belostoma flumineum,* ten *Ranatra americana* and ten *R. kirkaldyi* were placed in a cage ($7 \times 10 \times 5$ inches) made of wire gauze and this was then completely emersed in water so that it was two inches below the surface-film. The temperature of the water was 20° C. and of the atmosphere 23° C. In these experiments it was found that *Belostoma* and the two species of *Ranatra* died, on an average, within twelve hours. This result, however, would probably vary with the general activity of the aquatic bugs and the temperature of the water, since in the winter time, when the water is coated with ice, Belostomas and Ranatras are unable to come to the surface of the water to get a fresh supply of air.

If Nepas are allowed to remain in a jar of water, containing no vegetation or anything upon which they can crawl to the surface, they will all sooner or later be drowned. We have kept Nepas alive three months in a flat dish with water in it, shallow enough for the insects to reach the surface with their breathing tube, by feeding them now and then with house-flies and dragon-fly nymphs.

Methods of Progression.—Packard (35, p. 158), Kirkaldy (28, p. 344 and 29, p. 154), Bueno (9, p. 53 and 12, pp. 1–4) and Brimley (1, p. 88) have all discussed the method of progression of various aquatic-bugs, and Bueno (12, pp. 2–3) has made a detailed study of the method of swimming in *Belostoma flumineum.*

While *Belostoma* can swim with exceeding rapidity, *Nepa* makes but slow progress in water. *Belostoma, Lethocerus, Benacus, Nepa* and *Ranatra* alternate the movements of the hind pair of legs with

the middle pair in swimming; the front legs play no part in this method of progression, for they are extended forward on each side of the head, ready to seize an object upon which to come to rest.

In locomotion on land, however, the legs move in an entirely different manner from what they do in swimming. *Belostoma* and *Nepa* use all the legs in walking. In crawling, *Belostoma* alternates the movement of the hind legs, as well as the middle legs, but in swimming each pair of these legs moves simultaneously. Brimley (1, p. 88) claims that *Benacus griseus* while crawling, moves the hing legs together at first, "and afterwards when he got used to the situation, alternately...." When *Ranatra americana* is taken out of the water and is not thrown into the death feint it may, at first, give the typical swimming movement, but later, the posterior pairs of legs move as in *Belostoma.*

Belostoma can occasionally be induced to take wing by a number of different methods. In one experiment fifteen of these bugs were taken out of the water, which was at 19° C., and exposed for one and a half hours to the temperature of the atmosphere at 21° to 23° C., when two specimens made eager efforts to escape by flying against the sides of the dish in which they were confined. While working on the effect that sunlight may have on the duration of the death feint, it was found that *Belostoma* sometimes takes wing after coming out of the inert state. A method which rarely fails to induce *Belostoma* or *Ranatra* to fly is to arouse the creature's phototactic reactions by means of an artificial light. Although *Nepa* is without doubt able to fly, in no case have we succeeded in making it take wing.

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THE RESURRECTION OF THYANTA CALCEATA SAY FROM SYNONYMY.

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Professor E. B. Wilson, of Columbia University, in his researches concerning the chromosomes of the germ cells of the species of *Thyanta* frequenting the eastern United States, came to the conclusion, from certain constant differences in the chromosomes, that there were two distinct, but closely related species of this genus which have hitherto been incorporated under *Thyanta custator* Fabr.[1] He turned all of his specimens over to me, including four specimens of *T. perditor* Fabr. from Jamaica, W. I., with the request that I work out the differentiation of the two species. At the same time Professor Wilson pointed out to me certain differences in the shape of the scutellum by which alone he was able to separate the two species.

Since receiving this material I have endeavored to gather speci-

[1] Professor Wilson states in his paper before the Seventh International Congress in 1907, printed 1909, that he is readily able to differentiate the two species from a microscopical examination of their germ cells, as *T. calceata* has 27 chromosomes in the male and 28 in the female, while *T. custator* has 16 chromosomes in both sexes.